NUI Galway
OÉ Gaillimh

Semester 2 Examinations 2021/2022

Exam Code(s)	4BCT, 4BP, 4BLE
Exam(s)	B.Sc. in Comp Sc. & Information Technology B.E. in Electronic & Computer Engineering B.E. in Electrical & Electronic Engineering
Module Code(s)	CT420
Module(s)	Real-Time Systems
Paper No.	1
Repeat Paper	N
External Examiner(s)	Dr. Ramona Trestian
Internal Examiner(s)	Prof. Michael Madden *Dr. Michael Schukat

Instructions: Answer question 1 and 2 other questions.

Duration	2 hours
No. of Pages	5
Discipline	Information Technology

Requirements:

MCQ
Handout
Statistical/ Log Tables
Cambridge Tables
Graph Paper
Log Graph Paper
Other Materials

Release to Library: Yes [X] No [ ]

Q1 (Compulsory)
Consider the following hypothetical scenario: As a response to the 2021 NUIG cyberattack, Computer Services decide to further tighten network security and block UDP port 123 at the University's main gateway. This port has been used for the NTP time synchronisation of all computers on campus. As an alternative a PTP-based synchronisation using a single GPS-enabled grandmaster is considered. A more detailed requirements analysis shows that most desktop and servers require time synchronisation within a few milliseconds that can be achieved using existing NICs and network infrastructure; however, a small number of computers based in a single building require synchronisation levels in the order of 100 microseconds or better.

(i) You are asked to outline the overall PTP architecture of the new system, thereby addressing the following:

a. The use of multiple domains and its support in the PTP protocol. **(1 mark)**

b. The appropriate implementation of both E2E and P2P synchronisation, including an outline of how both mechanisms work. **(6 marks)**

c. The appropriate use of Boundary Clocks and Transparent Clocks, outlining their inner workings. **(4 marks)**

d. Grandmaster redundancy and how this is achieved by the BMCA. **(2 marks)**

(ii) Halfway through the project a security assessment shows that GPS spoofing could impact on time synchronisation, therefore UDP port 123 is re-opened again and NTP as a backup protocol re-established. Please outline

a. what makes NTP such a robust protocol. **(3 marks)**

b. how both protocols may work in tandem to provide a robust time synchronisation. **(4 marks)**

PTO

Q2

(i) Construct a cyclic executive (CE) scheduler in pseudo-code or C-code for the set of tasks listed in the table below. **(2 marks)**

Enhance your code to recognise cycle overruns, for example as the result of asynchronous interrupts. **(3 marks)**

Task	Period (msec)	Execution Time (msec)
A	10	3
B	10	3
C	20	1
D	20	2
E	40	2

(ii) Using examples explain the Hamming (7, 4) code with even parity, highlighting its error detection and error correction capabilities. **(5 marks)**

(iii) Distinguish between RAID-0, RAID-1 and RAID-5, commenting on their characteristics and I/O performance. **(5 marks)**

PTO

Q3

(i) Discuss how a hyperbolic radio-based navigation system would work on the island of Ireland with 3 radio transmitters (1 master and two slaves) located in Dublin, Galway and Cork.

(5 marks)

(ii) The data below shows the output of the ntpq utility from 2 NTP clients, namely ClientA and ClientB. Based on the output, which client is most likely to deliver better synchronisation? Your answer should comment on redundancy, offsets, delay, stratum level and reachability.

(6 marks)

ClientA	**RefID**	**st**	**t**	**When**	**Poll**	**Reach**	**Delay**	**Offset**	**Jitter**
+server1	serverx	2	u	51	64	156	391.281	6.24	7.79
-server2	servery	2	u	49	64	372	353.217	10.435	1.663
*server3	serverz	2	u	50	64	356	85.688	2.465	2.666
+server4	.PPS.	1	u	49	64	357	66.369	1.858	2.105
ClientB	**RefID**	**st**	**t**	**When**	**Poll**	**Reach**	**Delay**	**Offset**	**Jitter**
+server5	serverm	2	u	45	64	377	36.345	2.24	3.458
-server6	servern	2	u	42	64	377	313.217	3.435	1.11
*server7	.PPS.	1	u	13	64	377	10.688	1.485	1.455
+server8	.PPS.	1	u	22	64	377	28.456	1.818	1.345
+server9	.GPS.	1	u	18	64	356	15.345	-2.654	2.34

(iii) Explain how you would estimate the worst-case execution time of the code fragment below. In your answer refer to loop bounds and identify the (in your opinion) longest path.

(4 marks)

```
   const int max = 100;
   foo (float x) {
A:   for(i = 1; i <= max; i++) {
B:     if (x > 5)
C:       x = x * 2;
       else
D:       x = x + 2;
E:     if (x < 0)
F:       b[i] = a[i];
G:     x = x * 2;
      }}
```

PTO

Q4

(i) Using an example consisting of three processes that share some resources, show how the Priority Ceiling Protocol prevents a deadlock situation.

(8 marks)

(ii) Distinguish between the following voter types:

a. Formalised majority voter (FMV)
b. Generalised median voter (GMV)
c. Formalised plurality voter (FPV)
d. Weighted averaging (WA)

(2 marks)

(iii) Using code snippets show how a dynamic software redundancy approach can be emulated in Java using exception handling.

(5 marks)